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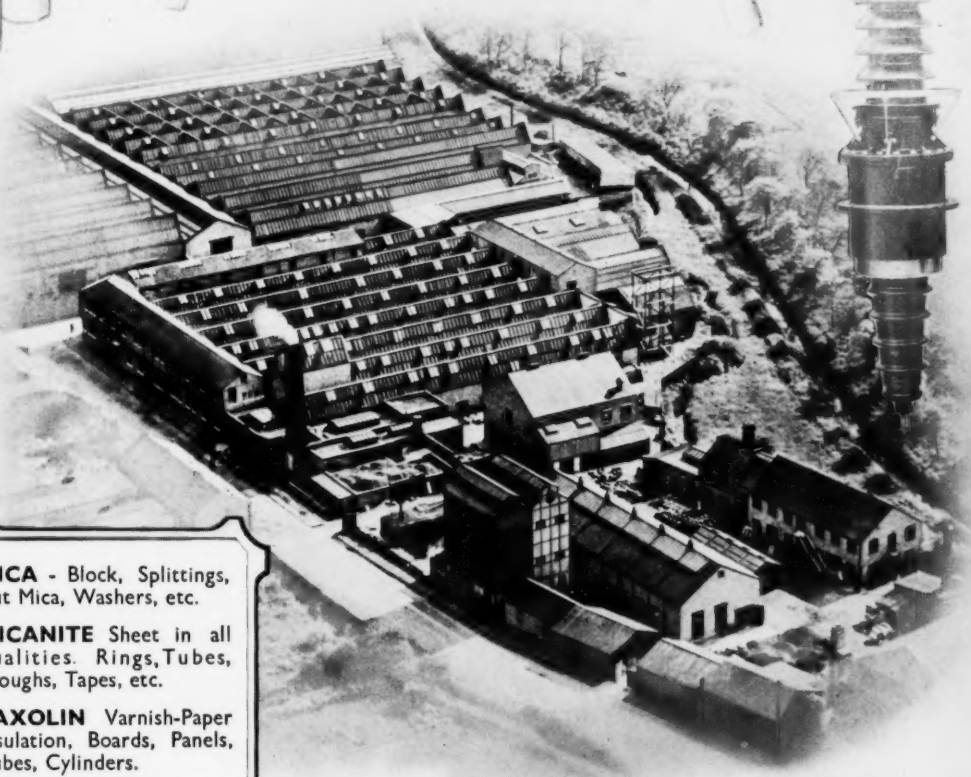

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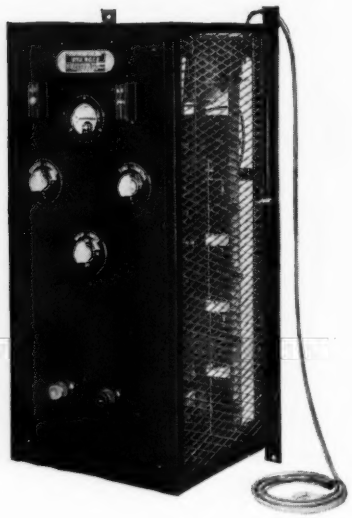

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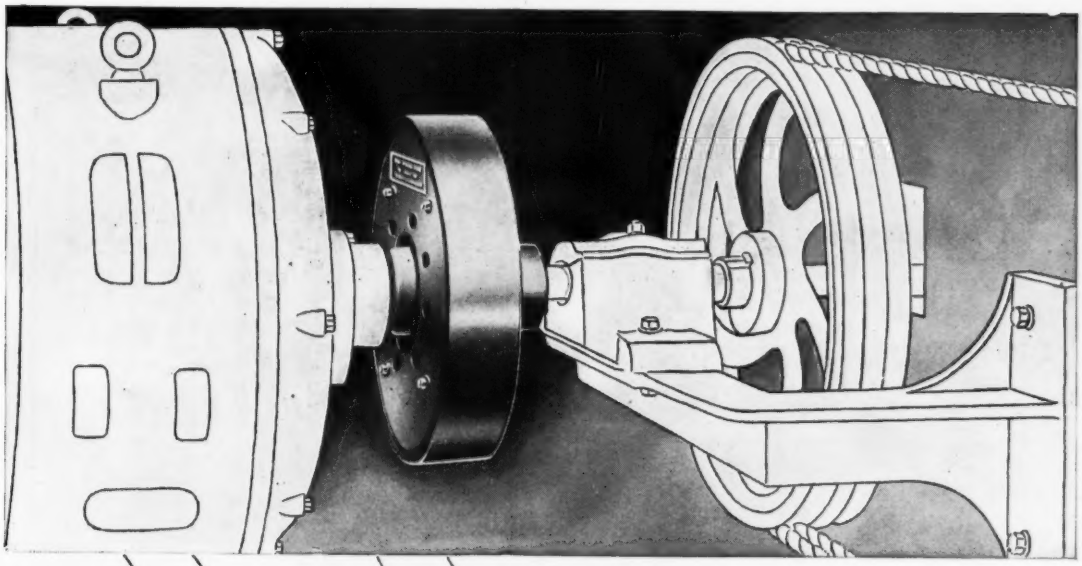

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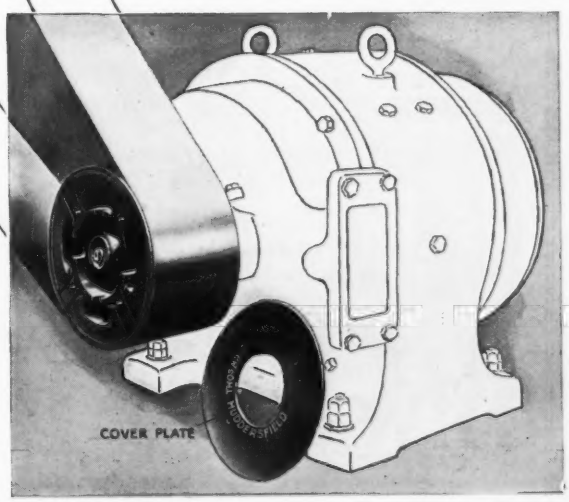

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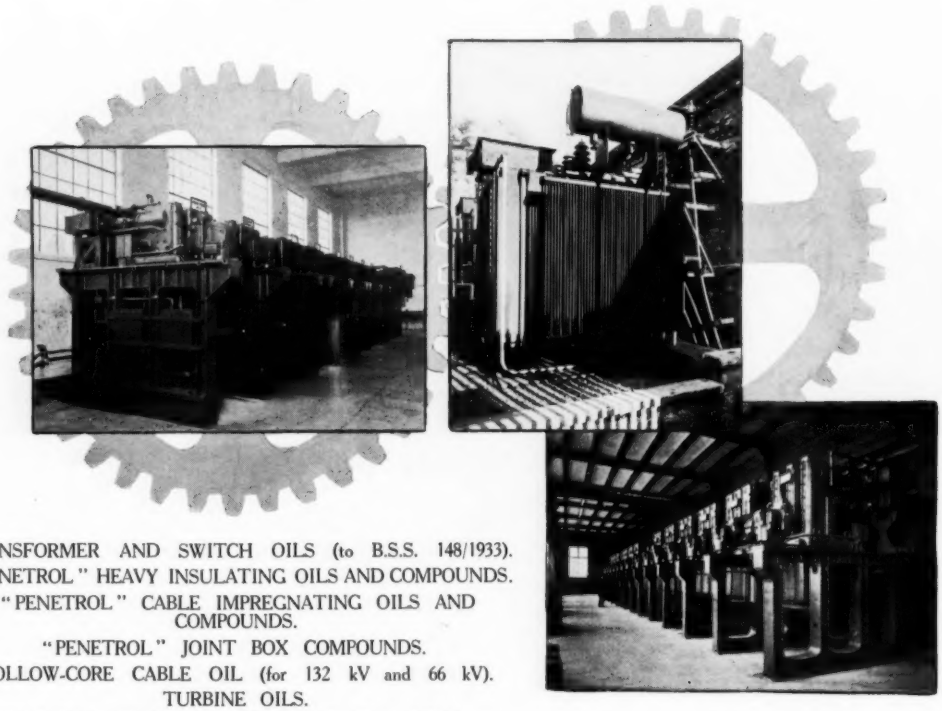

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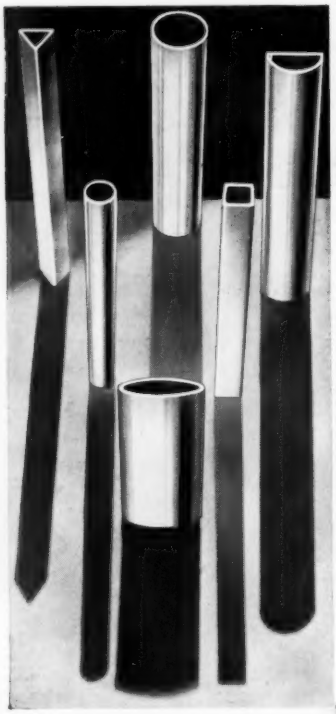

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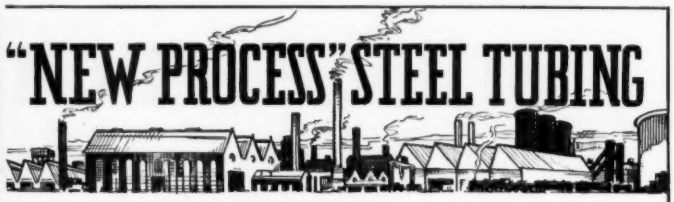

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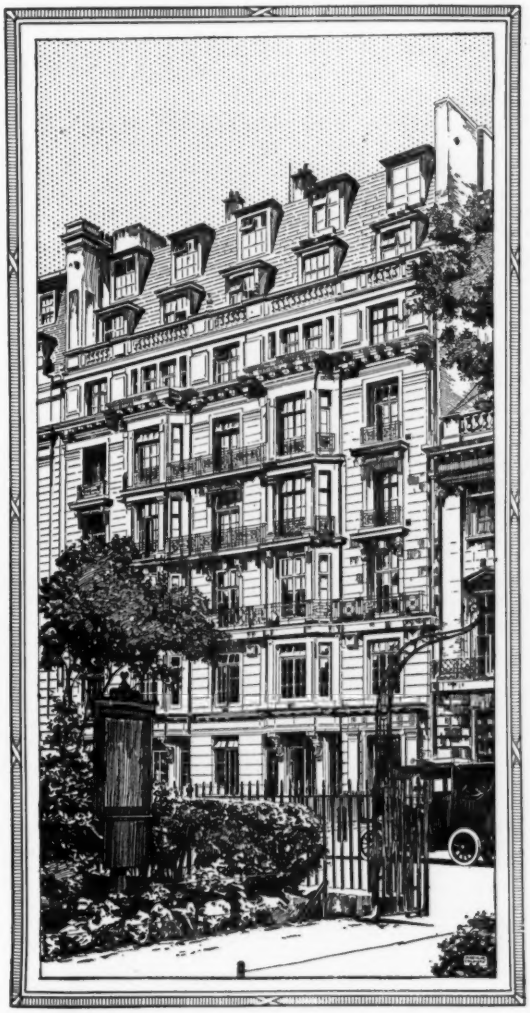

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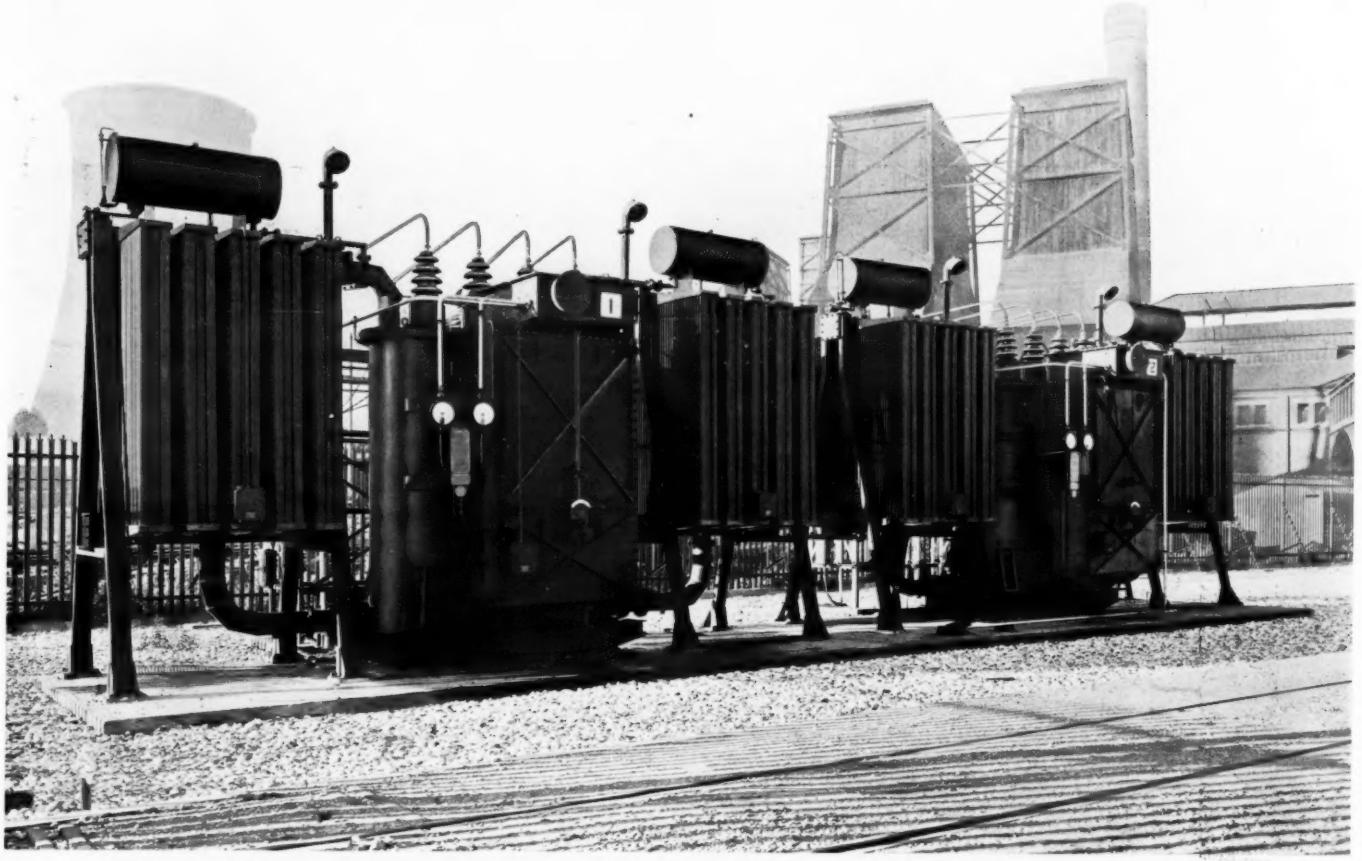

10,000 kVA Transformer Units at the Croydon Sub-station of the Central Electricity Board.

The English Electric Journal

Vol. VI. No. 6 SEPTEMBER, 1933 One Shilling.

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All Communications respecting Editorial Contents should be addressed to THE EDITOR, THE ENGLISH ELECTRIC JOURNAL, THE ENGLISH ELECTRIC COMPANY LIMITED, STAFFORD.

EDITORIAL.

Many of our readers will have seen in the Daily Press and in the Technical Journals, reference to the signing, at the Company's Offices in London, of a contract involving the sum of £2,000,000 for the electrification of the main Warsaw Junction Railways.

The contract provides for the supply and erection of a large quantity of railway material, comprising locomotives, motor-coaches, overhead-line equipment and substation work, and includes the necessary finance for certain civil engineering work associated with the electrification. The system adopted is 3,000 volts direct current.

The negotiations on behalf of the associated British interests were carried out by Mr. G. H. Nelson, the Chairman

and Managing Director of our Company, and their successful culmination was largely due to the full co-operation between the Prudential Assurance Company, the British Overseas Bank, and the two contracting firms; The English Electric Company, and The Metropolitan-Vickers Electrical Export Company. The award of this contract follows on earlier contracts for large generating and traction plants which were placed with our company by the Polish Authorities. One of the articles in this issue gives a description of the new electrification scheme and of the work to be carried out.

Further articles in the issue describe the latest developments in our Switchgear and Fuse-gear Departments. These include an auto-reclose switch equipment, and a new drop-down oil-break switch unit; while the description of the latest form of fuse units will, we believe, be of much interest to engineers engaged on distribution work. These units are simple, easily accessible, and capable of modification and extension; and not least important, they occupy a minimum of space. The demand for these units is rapidly increasing.

In our last issue we described the Dick, Kerr Luxury Coach, which is the last word in road-coach construction, and we follow in this issue with a description of what may be termed the Luxury Tram-car. This likewise has been constructed at our Preston Works, and is no less attractive both as regards comfort and appearance. This car will be in service all the year round on the Blackpool—Fleetwood route, and has been specially designed for both winter and summer use. Recently the Company received an order for twenty-four similar vehicles.

The article on "Rural Electrification" is concluded in this number. The subject is one to which we have devoted much attention, and the Company is in a position to give expert advice and service to all who are interested in rural electrification projects.

Electrification of the Warsaw Junction Railway.

Immediately after the War, Poland found itself in particular need of greater and more efficient transport facilities. The Polish Government, therefore, took the matter in hand with enterprise and energy, and recent developments include the construction on modern lines of a Port at Gdynia, together with the necessary railway communications and improvements to the railway facilities in many of the larger cities.

The largest city in Poland is Warsaw, which has a population of 1,110,000; and for some time the inconvenient lay-out of the railway tracks had been the cause of much congestion of traffic and loss of time in moving trains from one side of the city to the other.

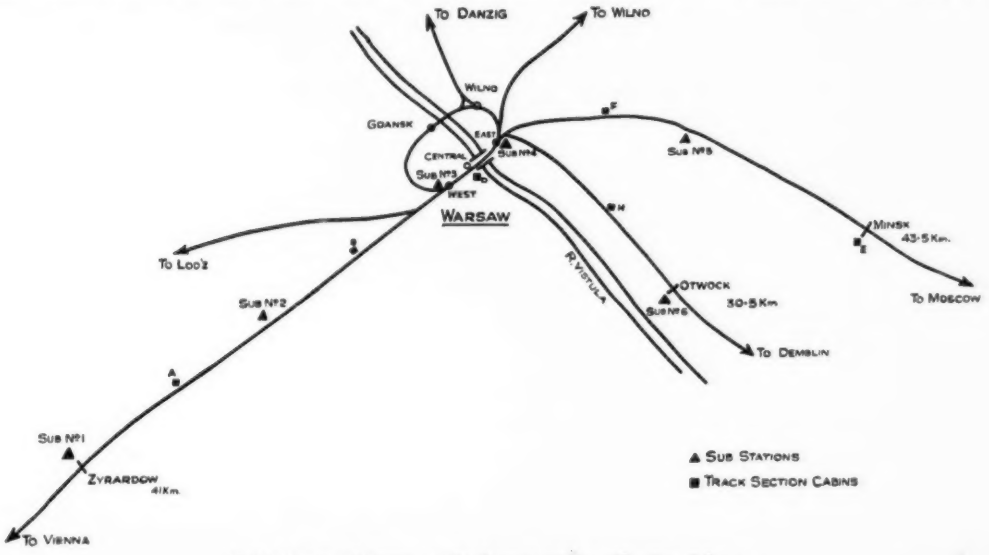
As can be seen from the map, there are at present four principal stations in Warsaw—namely, Central and Gdansk on the left bank of the Vistula, and East and Wilno on the right bank, all of which are connected by a loop line which runs round the north side of the city.

These four stations are fed by six different main lines, two lines entering Warsaw from the west, coming from Vienna (*via* Piotrkow), and from Lodz, while four lines enter the city from the east, coming from Danzig, Wilno, Moscow and Demblin.

All through traffic from east to west, and *vice versa*, as well as all express trains for the east, which start from Central Station, have to run round the loop to the north of the city, and, as this loop is also used for freight and local traffic it can be readily seen that congestion was inevitable with increased traffic, and train movements were made extremely difficult.

The Polish Government therefore investigated this problem and finally decided that the best solution would be to construct a new line across the city, part of which would be in a tunnel, and to build a new bridge and viaduct, so as to connect the Central and East Stations. This will permit closing the Wilno and Gdansk Stations, and all passenger traffic will be concentrated at the new Central Station.

The new railway bridge over the Vistula mentioned above is about 500 m. in length, and has already been completed; and a cut and cover tunnel has been driven under the Aleja Jerozolimska. This tunnel carries two tracks, and is under one side of the street, there being space



Polish State Railways. Sketch-map of Electrification Scheme.

for a tunnel with two more tracks under the other side of the street when they become necessary.

The tunnel, bridge and railway connections are practically finished, but very little work has been done yet on the new Central Station. This will be a monumental building with the tracks below and a concourse and offices above.

In order to operate trains through the tunnel, electrification is essential, and it has been decided to electrify three of the most important lines radiating from Warsaw—namely, the Piotrkow line as far as Zyrardow (41 km.), the line to Moscow as far as Minsk (43½ km.), and the Demblin line as far as Otwock (30½ km.).

Multiple-unit stock will be used for the local passenger services, whilst electric locomotives will be used to haul international and through expresses on the new junction line.

There is fairly heavy passenger traffic on all these lines, and the 1931 statistics give the following figures for passengers carried per annum :—

	Millions.
On the Zyrardow Line—	
Warsaw to Skierniewice	12.29
On the Otwock Line—	
Warsaw to Pilawa	4.91
On the Minsk Line—	
Warsaw to Mrozy	3.65

The actual traffic density between Warsaw and Zyrardow, Warsaw and Otwock, Warsaw and Minsk, would, of course, be greater than these figures, as each of these towns is closer to Warsaw than Skierniewice, Pilawa and Mrozy, for which routes the statistics were compiled.

In order to obtain a comparison, it is of interest to examine these figures in conjunction with the traffic densities of other lines for the last year of steam operation before going over to electrification.

For this purpose the table given below has been compiled, and it will be seen that the three lines radiating from Warsaw, which it is now proposed to electrify, compare very favourably from the point of view of traffic density alone with lines in other countries which it has been found an economic proposition to electrify.

As mentioned above, the first sections to be electrified are from Warsaw to Zyrardow, Otwock and Minsk, but extensions are contemplated in the near future beyond Zyrardow to Skierniewice, and this can only be the beginning of a general electrification scheme for all lines radiating from Warsaw.

After careful examination of all conditions, the Technical Commission appointed by the Polish Ministry of Transport recommended the adoption of 3,000 volt d.c. as the best system to be used, and the locomotives, motor-coach equipments, and plant to be supplied for this contract will be suitable for operation on this voltage.

STATISTICS FOR LAST YEAR OF STEAM WORKING.

Railway Lines.	Last year of steam working.	No. of passengers per annum in millions.	Route mileage.	Passengers per route mile per year in ten thousands.
Southern Railway—				
London-Brighton Section ...	1913	14.8	19.89	74.5
South-Western Section ...	1915	24	50	48
Warsaw-Skierniewice	—	12.29	41	30
L.M.S.—				
Liverpool-Southport	1904	7.8	26.25	29.7
Euston-Watford	1913	7	27.13	25.8
L.N.E.R.—				
Tynemouth Branch	1904	6.2	31.75	19.5
Warsaw-Pilawa	—	4.91	33	14.9
Rotterdam-Hague	1906	1.9	19.8	9.6
Warsaw-Mrozy	—	3.65	42	8.7

Six sub-stations will be provided, located as shown on the map, and the converting-plant will consist of mercury-arc rectifiers, together with the necessary transformers, switchgear, high-speed breakers and auxiliaries, the total capacity to be installed being 29,500 kW.

Five of these sub-stations will be equipped with supervisory control apparatus, four of them being controlled from the nearest passenger station, while the fifth, namely, Warsaw East Sub-station, will be controlled from Warsaw West Sub-station, which latter is arranged for manual operation.

Six locomotives will be provided, which are primarily intended for handling the international and express trains, as well as freight trains, on the electrified sections in Warsaw, after the steam locomotives have been detached.

They will be of the box-cab type, and have a B + B wheel arrangement, the bogies being connected together with an articulated coupling so as to relieve the superstructure of all strains. The locomotives will be equipped with four motors of the forced-ventilated type, each rated at 550 h.p. on 1,500 volts, two being connected in permanent series for operation off the 3,000-volt trolley system.

Electro-pneumatic control gear will be provided, and each locomotive will be equipped with two air-operated pantographs, compressed-air braking, and all necessary auxiliary apparatus.

For the multiple-unit suburban stock 80 motor coach equipments and 250 trailer-coach equipments will be supplied, complete with all apparatus to enable trains of various units to be made up as required.

The motor coaches will be arranged with a driver's compartment at each end, and the control apparatus will be mounted in a special compartment immediately behind one of the driver's compartments.

Each motor coach will be equipped with four 200 h.p. 1,500-volt self-ventilated motors, two motors being connected in permanent series to operate off the 3,000-volt trolley system. A motor-generator will be supplied with each equipment to provide a low-voltage supply for lighting and for the operation of the control apparatus.

Two air-operated pantographs, which can be controlled from the driver's cab, will be mounted on the roof of each motor coach. Heating will be carried out direct from the 3,000-volt trolley supply, and the necessary control apparatus, couplers and jumpers, etc., will be provided to enable the feed for the heating on trailer coaches throughout the train to be taken from the motor coaches.

A battery of 50 ampere-hour capacity will be provided on each motor coach, together with the necessary ancillary apparatus to enable half the lighting load to be supplied by the battery in an emergency.

The apparatus for the 250 trailer coaches comprises heaters, cable, conduit, couplers, etc., and, in addition, the necessary apparatus, such as master-controller, control switch, pantograph switch, etc., to enable 60 of these trailers to be arranged as driving-trailers if necessary.

Due to the great range of temperature and high winds experienced in Poland, great care was required in designing the overhead contact line system, and after careful investigation it was decided to provide the single catenary type of construction supported from steel poles by side bracket arms.

The normal spans will be approximately 72 metres in length, and weight-tensioning of both the catenary and trolley wires will be provided at approximately every 1.3 km., which will thus keep the trolley wires level under all conditions of weather.

The catenary will be of cadmium-bronze, and two trolley wires will be used, each having a cross section of 100 sq. mm., supported by alternate droppers direct from the catenary.

The whole of the overhead contact line will be divided into sections by six track-sectioning cabins, in which will be installed the necessary high-speed breakers to enable any section of the line to be isolated in case of a fault.

A New Type of Tramcar Constructed for the Blackpool Corporation.

The well-known Blackpool motto " Progress " is exemplified in the new tramcar which has been designed by the Transport Manager, Mr. W. Luff, the development and the work being executed by The English Electric Company, Limited. The body, of registered design, and the trucks are manufactured at the Company's Dick, Kerr Works, Preston, and the electrical equipment at the Phœnix Works, Bradford.

Apart from the fact that the vehicle is essentially modern in appearance, another object in providing this new car is to give an accelerated service, and this has been achieved by giving additional speed to the vehicle, and by providing better entrance arrangements to give more speedy loading and unloading facilities.

As the car will be principally used on the run between Blackpool and Fleetwood, a good observation type of vehicle was required, and with this object in view, passengers' vision has been a primary consideration both by means of the normal windows and in this case by the provision of side eaves of plate glass. Thus this type of car apart from its normal service will be particularly useful during the annual illuminations period, when it is very necessary that passengers can make observation easily, and at the same time be fully protected during inclement weather.

The body, which is of the centre-entrance type, seats 52 passengers, and being of streamline shape, has an exceedingly good appearance. It is mounted on two equal-wheel bogie trucks, having wheels of 27 in. diameter to enable very

The new car for Blackpool Corporation. Each of the two saloons has a sliding roof.

low loading to be provided, and to make it possible for the overall height of the vehicle to be less than 10 ft.

Passengers enter at either side of the car, at the centre, dependent on the direction of motion, and they step directly on to the entrance platform or vestibule without the intervention of any step arrangement. On each side of the vestibule is a saloon seating 24 passengers, all seats being of the transverse reversible type. Seats of the spring-loaded tip-up type are provided in the vestibule to accommodate 4 passengers.

At each end of the car is a totally-enclosed driving compartment, the driver having access to this compartment from the exterior of the car by means of a door on the offside, and, furthermore, another door is provided immediately behind the driver for access into the saloon.

Special Constructional Features.

In construction the body may be termed "composite," as its principal members are composed of rolled-steel sections and teak; the underframe is of welded rolled-steel sections.

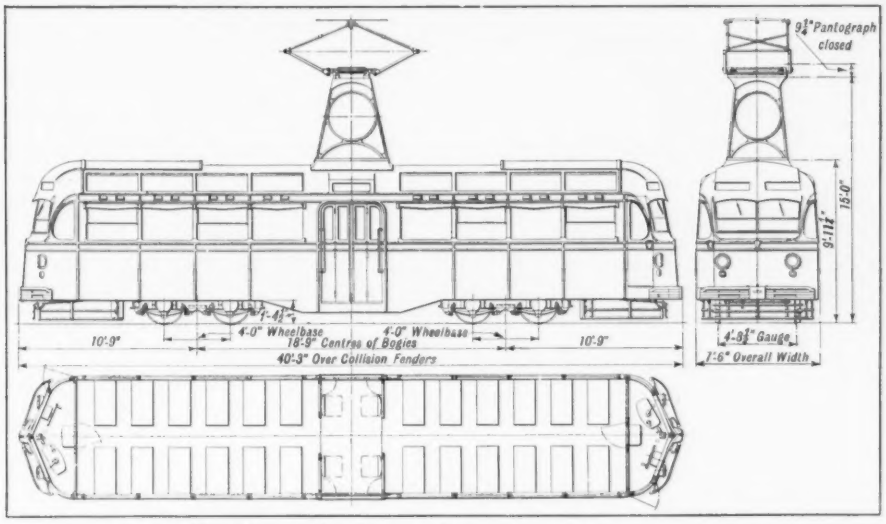
Special attention has been paid to the ventilation of this car and apart from a large number of ventilators fitted on the side facia panel, the roof of each saloon can be opened in fine weather by means of a large sliding panel. The sliding roof in each compartment is controlled by the conductor, and can be locked in any desired position. Furthermore, two windows on each side of each saloon are fitted with the latest half drop type of fittings with stainless-steel framing, while louvres are provided throughout the length of the vehicle to enable the half-drop windows to be left partially open when required.

Electric heaters of the tubular type are installed at each side of the car, these being controlled by the driver. In cold weather they will comfortably heat the car throughout.

In the vestibule and gangways the floor covering is of a green and mottled-brown rubber to harmonise with the interior decoration.

The interior woodwork of the saloons is of polished mahogany, while the lining panels are covered in scratch-proof material to tone. The ceilings are panelled and are of a pleasing design shaded in a warm orange tone with the embellishment in the design picked out in green. The furniture is principally of stainless steel.

The saloon seats are furnished with rubber



Elevation and plan drawing, showing the general arrangement.

cushions, and are upholstered in a tasteful design of green moquette and green leather. A cool pleasing effect has been generally obtained in the interior of the car, and passenger comfort has been considered in every way.

It is worthy of note that without restricting passenger space in any way accommodation is provided for 48 seated passengers in the two saloons, while the overall length of the vehicle is only 40 ft.

Interior Lighting.

One of the most important features of modern tramcar design is that of lighting, and in this car it has been so arranged that the intensive illumination is such that it will be possible for passengers to read in comfort, while at the same time glare has been obviated. The lighting fittings have convex glazed polished frames, and are fitted the full length of each side of each saloon. In the vestibule a rectangular panel glass fitting is provided, and this illuminates both vestibule and entrances.

The general appearance at the ends of the car is considerably enhanced by the provision of two headlamps, and also by the use of spring steel fenders of the type which has been made popular on the ordinary private motor car. Two adjustable wind screens are fitted at each end of the car, and each is fitted with an electric wind-screen wiper having a large area of operation. The normal type of mechanical sand gear is provided.

Communicating bells from the saloons to the driver are of the electric type, and a pneumatically-operated warning-whistle is fitted for the use of the driver.

Hand-brakes are actuated by a polished vertically-operated handwheel, suitable reduction gear being provided to minimise the manual effort. In addition to this manually-operated brake, air braking, operating on all wheels, is provided.

A view showing the adjustable wind-screens, the headlights, the spring-steel tender and the life-guard.

Two destination indicators are provided in the canopy over the driver at each end, and over each entrance doorway a large indicator is fitted; all of these are directly illuminated.

The life-guard and side-guards are of tubular metal construction of orthodox design, in order to meet the Ministry of Transport requirements.

The body is mounted on two equal-wheel bogies having a 4 ft. wheelbase which have been designed specially for this tramcar. Rolled-steel disc-wheels 27 in. diameter are fitted, and the side frames consist of steel plates. The brakes operate shoes on all wheels.

Springing.

Special attention has been given to the spring-

ing so that heavy overloads can be carried without unduly stressing the springs. On the other hand, with light loads, special spring arrangements allow for equally easy riding qualities. Long leaf semi-elliptic springs with auxiliary rubber pads are carried under the axle-boxes, these operating in conjunction with a fully sprung swing bolster.

The axle-boxes are of the semi-spherical roller-bearing type so arranged to eliminate wheel wear when cornering. To minimise any noise usually associated with the use of equal wheel trucks silent-bloc bushes have been fitted. The bogie trucks are of compact design, and each is fitted with one E.E. 305 Motor, a description of which is given below.

Motors.

The electrical equipment consists of two motors with series parallel control. The motors are the E.E 305 type, rated at 50 h.p., at 500 volts, of modern light-weight construction, with Class B insulation and drive through spur gearing directly on to one axle of each bogie.

A special feature with which these motors are provided is the " English Electric " constant level lubricator. While the armature bearings are of the standard roller type, the axle suspension bearings are of course oil lubricated, and an oil container, certain details of which have been patented by the English Electric Company, is fixed to each motor which keeps a constant oil level in these bearings. The supply of oil in the containers is sufficient to maintain the bearings for from four to five months, thus greatly reducing the attention required by these bearings; and as the trucks are provided with roller-bearing axle-boxes, lubrication maintenance is reduced to a minimum.

Controllers.

There are two controllers, one at each end of the car, which provide four series, four parallel, and eight brake notches. These controllers represent the latest development in tramway practice. Tramway controllers in the past have been fairly clearly divided between the earlier drum-type and the later cam-type, but experience has shown that neither is ideal; this new controller contains the best features of both.

It is known as the " English Electric " " Z " type, and has the usual mechanical interlock between the driving-handle and the reverser. The principal feature is the division of the contacts into those which break current and those which carry current. There are two contactors provided for breaking current; a line contactor on the power side, and a contactor on the brake side.

The line contactor is fitted with the " English Electric " quick-break trip-mechanism, so that in shutting off the power, the current is entirely broken on this line contactor. The brake contactor is arranged so that the rupturing of the brake-circuits, when shutting off from " brake " to " off " position, is made on this contactor. The remaining contacts, including those for successively cutting out steps of resistance, are made on a power cylinder of the drum type fixed to the same shaft as the cams which operate the line contactors.

The contact fingers are fitted with individual blow-outs, and are of the self-adjusting type with renewable tips and helical springs. No current passes through the springs. The entire drum, consisting of the contactors and drum contacts is provided with an arc-shield of the swing-hinge type.

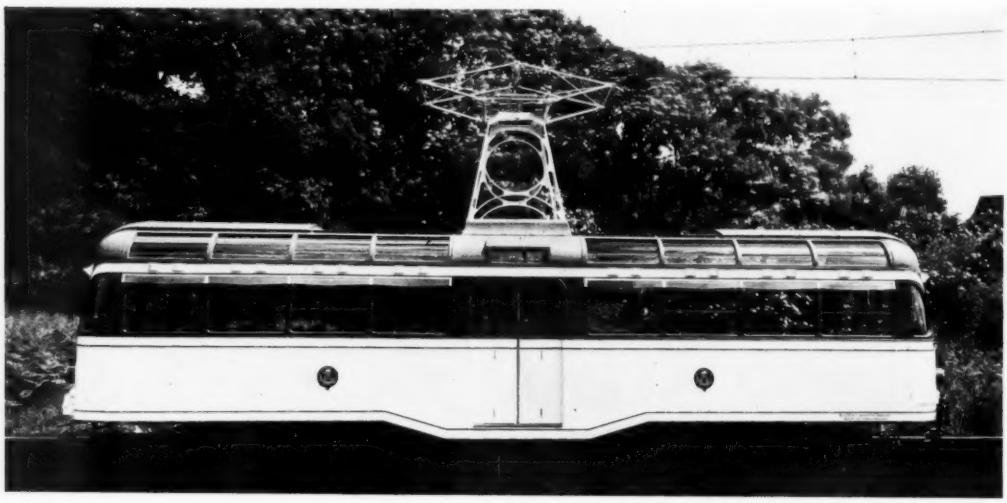
The reversing drum is of the standard type with means for cutting out either motor by means of the reversing key. Below the reverser is a brake power change-over switch; this is a switch of the two-position type so that the circuits are set up either for power or for brake, and this contributes to the ease of manipulation of the controller. Further, as this switch is only moved from " off " to " brake," there is a big reduction in the amount of wear on contacts and fingers as compared with previous types. All contact fingers of the reverser and brake switch are also of the self-adjusting, helical-spring, renewable-tip type. The controller is exceedingly accessible, and ample space has been given so as to ensure easy maintenance.

A further special and patented feature embodied in this controller is that all incoming leads are brought to terminals on the right-hand side of the controller, and enter through a casting secured to the car floor, and also secured to the

controller when in position. To remove the controller for general overhaul, it is only necessary to disconnect the leads, unscrew two bolts in the floor casting, and the controller can be moved away, leaving all the cables in position without having to drag the leads through a hole in the controller casing. The advantages of this for maintenance operations will be readily appreciated.

Pantograph.

Current collection is by means of an " English Electric " pantograph, mounted on a structure built on the car roof. This pantograph has special features, on which patents have been applied for. It is of the single pan, sliding collector type, operated by means of adjustable tension springs, with the spring tension applied through cams to keep the pressure uniform over the whole working range. The construction is in accordance with best railway practice, the framework being of steel tubing with cast-steel sockets and tubular cross bracing. The joints are fitted with self-adjusting ball-bearings and are shunted with flexible copper pigtails. The pantograph is controlled by a standard trolley cord with the addition of a simple locking device to hold the pantograph closed in the lowered position.



A side view of the new Blackpool car.

A cordial invitation is extended to all our readers to visit our Stand at the Commercial Motor Transport Exhibition at Olympia, November 2nd to 11th.

OUR STAND
No. 113 ANNEXE

We are showing a double-deck four-wheel trolley-bus and a bus body mounted on a petrol-driven chassis.

Recent Developments in the Switchgear and Fuse-gear Departments.

Vertical Isolation Switchgear—Type "DD"

In order to meet the increasing demand for an inexpensive oil circuit-breaker unit which will occupy the minimum building space, but at the same time will incorporate many of the advantages of the orthodox metal-clad compound-filled draw-out-type switchgear, including reliable and definite performance, the company has recently developed the "DD" vertical-isolation metal-enclosed drop-down unit, typical illustrations of which appear in Figs. 1 and 2.

The "DD" unit is designed for voltages up to 11,000 volts and for currents up to 1,200 amperes.

The main structure is of fabricated steel, and by use of adequate bracing members complete rigidity is obtained with the minimum of weight. The busbar and current-transformer chambers are located at the top of the unit, and are normally air insulated, but they can be oil or compound-filled if desired; the busbars in either case are wrapped with insulating tape to withstand the full voltage of the system.

The oil circuit-breaker, in the top of which are fitted the six self-centring isolating-plugs, is raised or lowered, vertically, by means of screwed rods actuated by a removable handle; and ball-bearings are fitted so that the minimum effort is required for this operation. Three positions of the breaker are provided for; the normal service or top position, occupied by the left-hand breaker shown in Fig. 1, in which the isolating-plugs engage with corresponding sockets fitted to the busbar and current-transformer chambers; the isolated or intermediate position, in which the right-hand breaker is shown in Fig. 1, the breaker being isolated completely from the busbars and circuit; the bottom position, in which the breaker rests on the floor and can be either wheeled away on its self-contained rollers, or the tank bolts can be removed, and the breaker raised to the "isolated" position, leaving the tank on the floor and the contacts exposed for inspection as shown in Fig. 2.

The unit is fully interlocked, rendering it impossible for an operator inadvertently to make contact with live parts, or otherwise to expose himself to danger through incorrect operation. Isolation cannot be effected without first opening the oil circuit-breaker; and when isolated, and with the tank removed, the breaker cannot be raised into the "service" position. Upon lowering the breaker into the "isolated" position, automatically-operated shutters cover the isolator socket apertures in the fixed upper portion of the unit. A top case of the requisite dimensions

Fig. 1. The left-hand unit is in the "service" position, and the right-hand unit is in the "isolated" position.

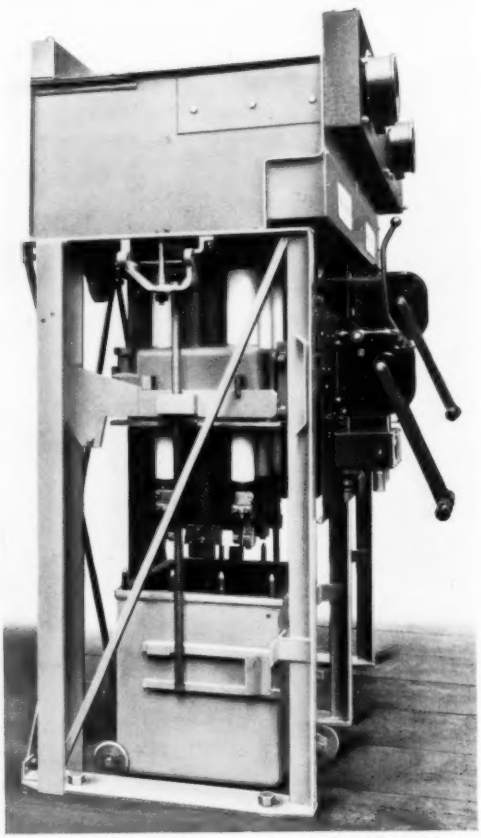


Fig. 2. A Type "DD" unit in the "isolated" position and with the tank removed for inspection of the contacts.

is provided to accommodate the usual instruments, meters, and relays.

Although all parts are conveniently accessible, access from the back is not required so that the unit can be mounted with its back close against a wall. The vertical system of isolation enables all usual inspections and adjustments to be carried out within the floor space normally occupied by the unit; but should it be necessary to remove the oil circuit-breaker completely, it will be seen on reference to Fig. 2, that the extra space required in front of the unit for this purpose is only a few inches beyond the projection of the operating handle. As a result of the foregoing features, and due also to the inherent compactness of design, the floor space required by the unit is reduced to a minimum, with a consequent considerable saving in the cost of the building for housing the switchgear. The standard unit is 6 ft. 5 ins. high, and 2 ft. 2 ins. wide between centres, and the overall depth from the back of the unit over the maximum projection of the operating handle is only 4 ft. 1 in.

The units can be mounted singly or any number can be mounted together to form a switchboard with continuous busbars. Oil circuit-breakers of similar current-carrying capacity are interchangeable and, since the units are completely self-contained, very little work is involved when erecting them on site.

The oil circuit-breaker is similar in all the important points of design to that incorporated in the standard "English Electric" metal-clad horizontal draw-out-type units, being of very massive construction throughout and designed to definite test data, so that reliable performance within its rated capacity is ensured.

All operating mechanism, except the handle and automatic trips, is enclosed in the top-plate of the breaker enabling it to remain effectively lubricated during long periods of inaction, and thus eliminating the risk of failure due to "sticking" when called upon to clear a fault. Further, the possibility of the breaker being re-closed by "piston action" after opening on

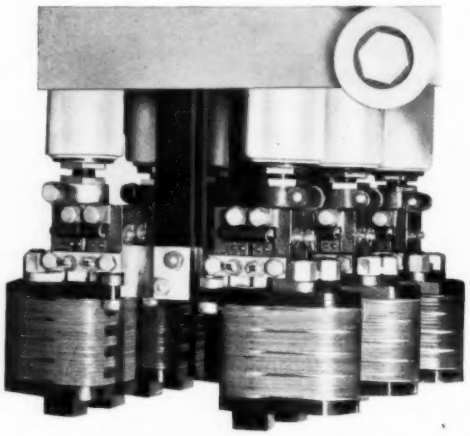


Fig. 3. A view showing De-ion Grid Contacts fitted to a Type "DD" circuit-breaker.

a fault is precluded, since all forces on the operating mechanism due to pressure in the tank are balanced. An efficient venting system is provided. The operating-handle is of the trip-free sensitive type with complete mechanical stability enabling very low settings to be obtained on, for instance, a direct-connected earth-leakage trip-coil, without danger of inadvertent operation due to vibrations. All the usual combinations of automatic features can be fitted including time-limit fuses for shunting the overload trip-coils.

An important feature of the oil circuit-breaker is that De-ion Grid Contacts can be fitted, a typical set being illustrated in Fig. 3. To be able to incorporate, in a relatively inexpensive switching unit, the well-known de-ionising method of arc control, representing as it does the most important advance that has been made in recent years in the improvement of oil circuit-breaker performance, is an advantage which requires no further comment here.

The " DD " type unit complies in all respects with the relevant regulations, is provided with ample clearances and insulation, and is subjected to standard B.S.I. pressure tests before despatch from the Company's works.

Automatic Re-closing Equipment.

The problem of maintaining the maximum continuity of supply on electrical transmission and distribution systems is assuming ever increasing importance in view of the wide areas to which electric power for all kinds of industrial and domestic loads is now supplied.

An interruption of service usually means serious inconvenience to the consumers affected, and considerable financial loss to the supply undertaking. Occasional failures of the supply are practically unavoidable as, for instance, in the case of a feeder fault; but if the service can be quickly re-established when such faults occur, the disagreeable consequences to both consumer and supplier are minimised.

Many faults which occur on feeders will clear themselves if given the opportunity, but usually this is impossible since the circuit-breaker protecting the line opens and the service affected is not restored until the breaker is re-closed by an attendant. In the case of unattended sub-stations, considerable and unnecessary delay may occur in re-establishing the supply due to the time required for a man to reach the sub-station from the main station or elsewhere.

The foregoing considerations have led the Company to develop the automatic re-closing equipment described below and the long experience of the Company in the design, manufacture, and operation of automatic sub-station equipment has been drawn upon to ensure the high degree of reliability which is so essential.

The equipment is electrical in operation, experience having shown that mechanical methods of re-closing possess inherent disadvantages from the point of view of reliability.

Views of a typical equipment of the fabricated steel cubicle type (with screens removed), are shown in Figs. 1 and 3, and the diagram of connections, together with a schematic diagram of the operating circuits, is shown in Fig. 2. The equipment illustrated is actually for use on an 11,000-volt, 3-phase, 50-cycle system, but the automatic gear is standardised and can be applied to equipments of any voltage, current, and breaking-capacity.

In general, the equipment consists of a motor-operated oil circuit-breaker, connected in the feeder to be controlled, and fitted with automatic releases. When the circuit-breaker opens on a feeder fault it is automatically re-closed after a predetermined time interval; if the fault persists and the breaker again opens, it is re-closed at regular intervals for a predetermined number of times. Should the fault not have cleared itself after the full number of re-closures have taken place, the breaker will remain open until the mechanism is re-set by hand, whilst an alarm circuit is closed to indicate either locally or at a distant point, that the feeder is " locked out."

The number of re-closures can be adjusted between 1 and 9, and the interval between re-closing operations may be set from a few seconds up to three minutes. Should the oil circuit-breaker, having tripped and re-closed, remain closed for a longer period than the maximum possible setting of the overload time-lags, then the counting mechanism is automatically re-set to give again the full predetermined number of re-closures if a further fault develops.

Referring to the equipment illustrated in Figs. 1 and 3, the top compartment of the cubicle contains the busbars and isolating-switches; below this are the oil circuit-breaker, with tank removed, the current-transformers, and the feeder cable box. On the front of the cubicle at the top is the operating-motor for closing the oil circuit-breaker, with solenoid brake, reduction gear, and limit switches which are enclosed in a steel cover. This mechanism is coupled through cranks and links to the trip-free oil circuit-breaker operating-mechanism below, which is equipped with overload trip-coils fitted with adjustable air-vane time-limit devices. To the left of the operating gear is the oil-immersed vane-type time-delay relay for giving the desired intervals between re-closures, and the main circuit ammeter; beneath these are the triple-pole change-over auto-reclosing contactor, with mechanically coupled counting, lock-out and re-setting mechanism, three thermal time-delay cut-outs for protecting the operating-motor, and an intermediate relay for the alarm circuit. A double-pole tumbler switch, for cutting out the automatic re-closing gear and disconnecting the alarm circuit, and indicating lamps to show the open and closed positions of the circuit-breaker, are also included.

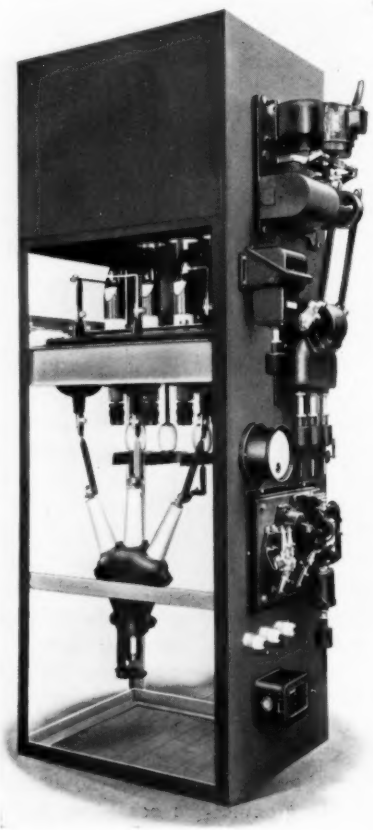


Fig. 1.

OPERATION.

Referring to the schematic diagram in Fig. 2 where all apparatus is shown in the position corresponding to the oil circuit-breaker being open and its operating mechanism in the "start" (or "re-set") position, the operation in detail is as follows:—

Assuming that the thermal cut-outs protecting the operating-motor are closed, and that the auto-reclose lock-out switch is in the "re-set" position, closing the double-pole tumbler-switch completes a circuit from the red phase of the operating supply through the lock-out switch, motor operating gear limit-switch (*d*), oil circuit-breaker auxiliary switch (*b*), to the re-closing time-delay relay and thence to neutral, and at the same time the alarm relay is energised thus opening the alarm circuit.

After a predetermined interval the contacts of the timing-relay close, completing the circuit to the auto-reclosing contactor, which in turn completes the circuits from the red and blue phases through the motor operating mechanism limit-switches (*e*) and (*f*) respectively to the operating motor and magnetic brake. At the same time the "make" auxiliary switch on the auto-reclosing contactor completes a retaining circuit across the contacts on the time-delay relay. The energising of the operating motor causes the oil-switch to close, the motor continuing to rotate until such time as the limit-switches (*d*), (*e*) and (*f*) break circuit on their lower con-

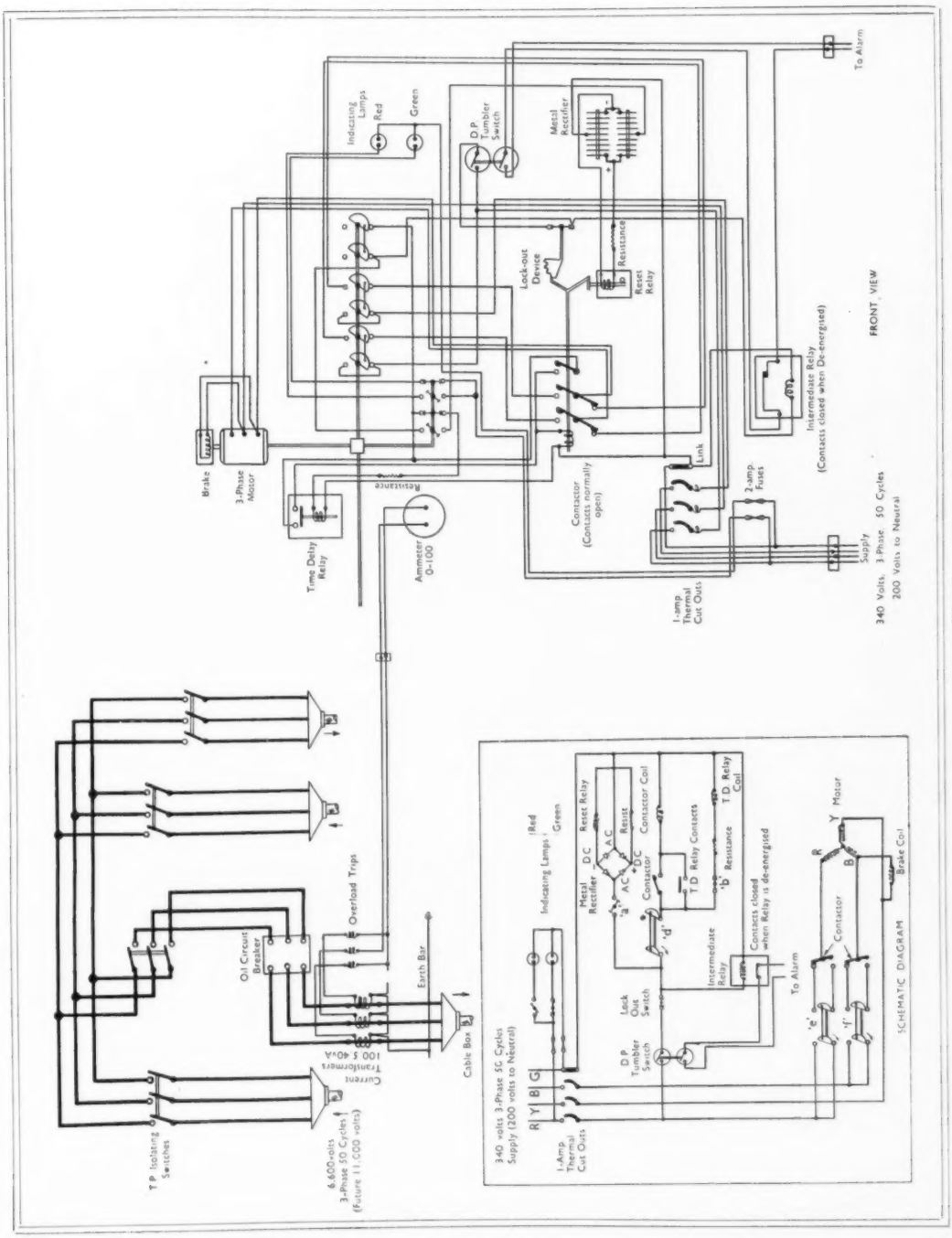

To Alarm
Indicating Lamps
Red
Green
D.P. Tumbler Switch
Metal Rectifier
Lock-out Device
Resistance
Reset Relay
Intermediate Relay
(Contacts closed when De-energised)
FRONT VIEW
Brake
3-Phase Motor
Resistance
Contactor (Contacts normally open)
Link
2-amp Fuses
Time Delay Relay
Ammeter 0-100
1-amp Thermal Cut Outs
Supply
340 Volts, 3-Phase, 50 Cycles
200 Volts to Neutral
T.P. Isolating Switches
4,600-volts 3-Phase 50 Cycles (Future 11,000 volts)
Current Transformers 100/5 40VA
Oil Circuit Breaker
Overload Trips
Earth Bar
Cable Box
340 volts 3-Phase 50 Cycles Supply (200 volts to Neutral)
R Y B G
Indicating Lamps
Red
Green
Metal Rectifier
D.C
A.C
Reset Relay
Resist
Contactor Coil
Contactor
T.D. Relay Contacts
T.D. Relay Coil
Resistance
Intermediate Relay
Contacts closed when Relay is de-energised
To Alarm
Lock Out Switch
D.P. Tumbler Switch
1-Amp Thermal Cut Outs
Contactor
Y Motor
Brake Coil
SCHEMATIC DIAGRAM

Fig. 2.

tacts, thus the supply is cut off from the motor, and at the same time the auto-reclosing contactor is de-energised. This latter operation completes the circuit to the operating motor through the top contacts of the limit-switches (*e*) and (*f*), so returning the operating mechanism to the "start" or "reset" position.

COUNTING DEVICE.

The operation of the counting mechanism is such that when the re-close contactor is de-energised after closing in the first instance, the mechanism is notched round one tooth; but provided the oil circuit-breaker remains closed the counting mechanism is re-set due to its coil being energised from the red phase, through the tumbler switch, the auto-reclose lock-out switch, the oil circuit-breaker auxiliary switch (*a*), the metal oxide rectifier and thence through the relay-coil to the neutral. The re-setting relay is provided with a time delay of longer duration than that of the overload trips on the oil circuit-breaker operating mechanism, in order to prevent the counting mechanism from being re-set before the overload trips have had time to operate and open the oil circuit-breaker, should the latter close on a fault or overload.

The closing of the oil circuit-breaker also causes the auxiliary switch (*b*) to open, breaking the circuit of the time-delay re-closing relay.

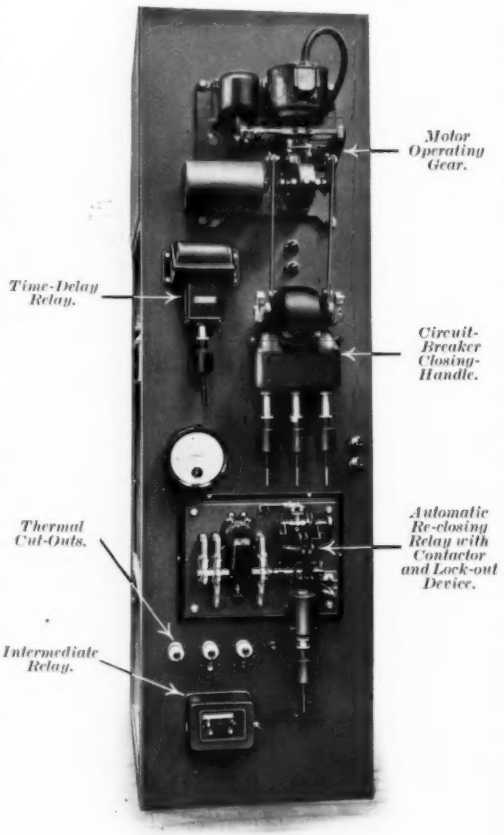


Fig. 3.

If, on the first attempt to close, the oil circuit-breaker trips out again due to a fault, the auxiliary switches (*a*) and (*b*) will be in their respective positions, as shown on the diagram when the motor operating mechanism returns to the "start" or "re-set" position. The time-delay re-closing relay will thus again be energised and, after a predetermined interval, cause the auto-reclosing contactor to operate and attempt a further re-closing of the oil circuit-breaker. Each attempt causes the counting mechanism to be notched round one tooth, and unless the oil circuit-breaker definitely remains closed for a time sufficient to allow the re-setting relay to operate, the mechanism will finally lock-out after the predetermined number of attempts have been made. The opening of the lock-out contacts cuts off the supply to the auto-reclose equipment, and also de-energises the alarm relay. This latter will therefore give an alarm whenever the mechanism locks out; but as the two poles of the tumbler switch are mechanically coupled, no alarm is given when the mechanism is merely switched off. It will be appreciated that the alarm relay also functions on failure of voltage. After a lock-out it is necessary to re-set the auto-reclose equipment by hand.

"English Electric" Fuse Gear.

Very satisfactory progress has been made in the development of new products and in the improvement of existing products at the Fuse Gear factory, and a brief outline of this progress is given in the following notes.

Skeleton Fuse Boards.

Figure 1 illustrates a typical skeleton fuse-board, of which type there are two standard sizes available ; one rated up to 400 amperes and the other up to 800 amperes. The illustration shows a transformer isolator-panel on the right-hand end of the board with metering equipment. On each distribution circuit double isolation of the fuse is provided, enabling it to be withdrawn and replaced in complete safety.

Metering of any kind can be incorporated, the simplest form comprising a clip-on transformer round the cable tails ; alternatively, a portable recording meter can be used, and for this purpose plug-contacts on the contact plates on each side of the lower isolator are provided. Whatever arrangement is adopted, it will be appreciated that the fuse is always in the live circuit on the busbar side of the meter.

The busbars and the cable-boxes are carried on the main structure, and the board as a whole is arranged for bolting direct on to the wall. They are entirely self-supporting, and no space is required between the wall and the back of the board as required by Home Office regulations for back-connected boards. The board is easy to erect, and extensions can be effected without interfering with existing circuits.

Universal Type Fuse Units.

In this unit the fuse contact-clips are supported on a vertical insulated rod and the busbars located immediately behind them. All connections are made from the front, and this, combined with the arrangement of the cable-box, which can be detached complete from the unit, makes connecting up a very simple process. This unit also, is designed for bolting direct on to the wall,

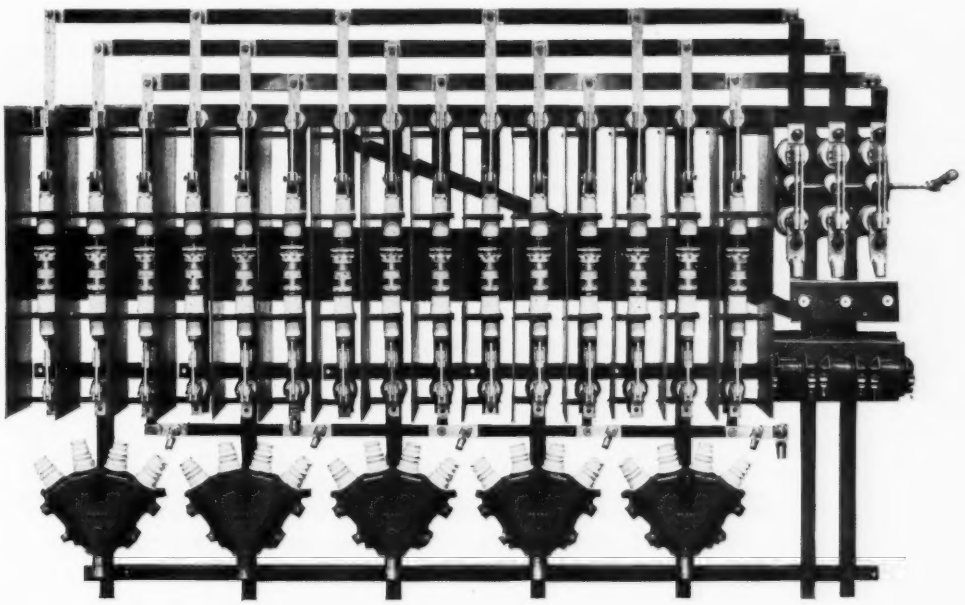


Fig. 1. A 5-way, 3-phase, 4-wire board with transformer feeder panel.

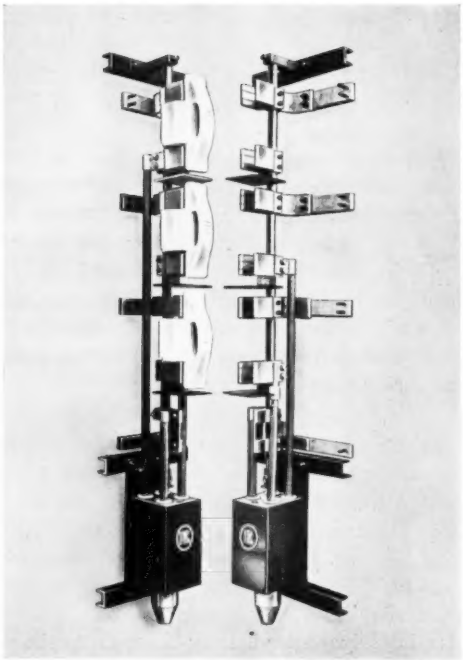


Fig. 2. A Universal Unit with back-connected busbars.

and requires no space between the wall and the supporting frame; any individual unit can be disconnected from the board, or erected to form an extension to the board, without interfering with the busbars or with adjacent units. Access from the back is not at any time necessary. The design permits of any circuit arrangement from single-phase and neutral, to three-phase four-wire plus lighting circuit by merely altering one component, namely, the length of the insulated supporting rod, and this feature gives the unit its name—the Universal Unit.

Figure 2 shows two views of an 800-ampere unit with the cable-tails extended from the cable-box and sweated into the cable-sockets provided on the fuse-contacts. This unit can be supplied in five different sizes for current-ratings of 60 amperes up to 800 amperes.

Ironclad Factory-type Distribution Board.

A new type of distribution board is illustrated in Figure 3. This board is very easy to install and connect, entirely safe in operation, and it complies with the latest Home Office requirements.

High-Rupturing-Capacity Non-Deteriorating Fuses.

The "English Electric" high-rupturing-capacity non-deteriorating cartridge-fuse has been developed especially to deal with circuit conditions where the power available on a fault is much beyond the capacity of an ordinary re-wirable fuse. These conditions to-day are so frequent as to render the application of the "English Electric" high-rupturing-capacity fuse practically universal. In addition to its use in the three specialised types of fuse gear first described, it is also very largely supplied as a complete unit to be built into all forms of distribution equipment. By the use of conversion handles a very large field is exploited; these can be fitted to existing fuse boards, disconnecting boxes, etc., to give the necessary short-circuit protection which is not provided by the original apparatus.

Motor and other control gear, having a rupturing capacity of a low order, may be safely installed on systems where the short-circuit power available is of the order of 25,000 kVA,

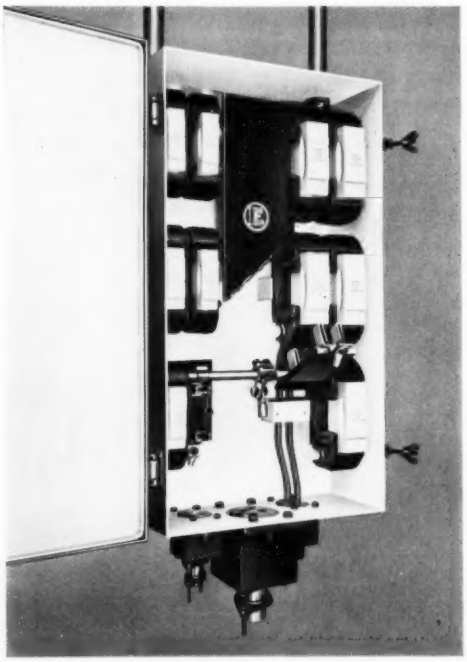


Fig. 3. A Factory-type Distribution Board.

because the fuse will clear the short circuit completely in a fraction of the time required by the control gear to operate.

Tag-type Cartridge Fuses.

One of these fuses is illustrated in Figure 4. The tags on each end of the fuse are secured by bolts or screws to the contacts of the apparatus in which it is to be used. This construction permits the use of handles for conversion purposes, for example, for use in contacts of other manufacture, frequently enabling a re-wirable fuse handle to be replaced by a fuse of our high-rupturing-capacity non-deteriorating pattern. This fuse is manufactured in all sizes from 2 to 800 amperes inclusive.

Tests of Performance.

During the past year more important independent tests have been carried out on the Company's fuses by three large Electricity Supply Undertakings, covering 500-ampere fuses at 400 volts d.c. and a large range of fuses up to and including 500-ampere sizes at 420 volts a.c. Two of these tests were of a competitive nature, and showed, that compared with fuses of other manufacture, the Company's fuse had the lowest internal resistance, thus developing the lowest heat; and also, the voltage rise on rupture was the lowest and our speed of rupture the highest. Figures obtained from one of these tests show that, taking the speed of rupture of the "English Electric" fuse as 1, those of the fuses of other manufacture were 2.5 and 13.

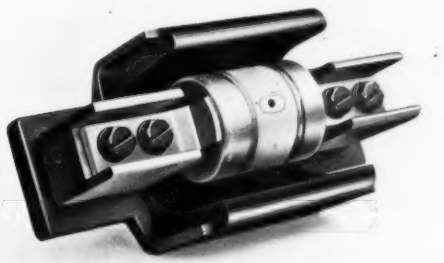


Fig. 4. A 500-ampere tag-type cartridge-fuse fitted in a moulded fuse-handle.

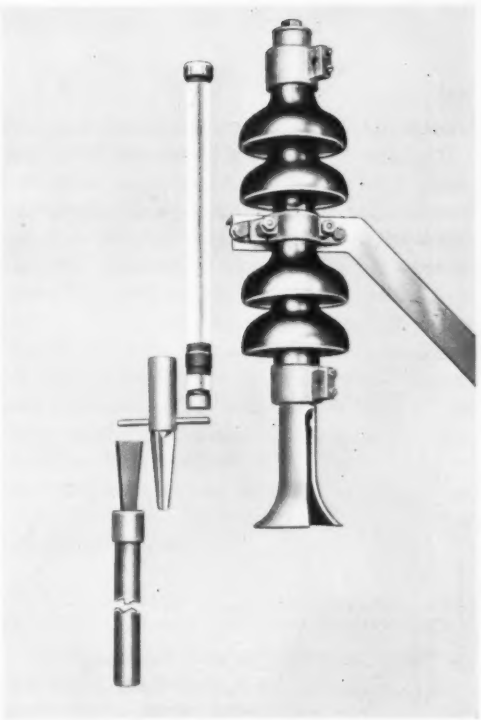


Fig. 5. A Type R.D. 11,000-volt pole-operated fuse-unit.

High-Voltage Fuse Gear.

The fuse standardised for the 11,000-volt Falling-Frame Switch-Fuse is the Type E.30, which has a maximum current rating of 15 amperes and a rupturing capacity of 100,000 kVA. It is interesting to note that this fuse has also been standardised by other manufacturers who have incorporated it in their designs.

Figure 5 shows the Type R.D. 11,000-volt pole-operated fuse-unit. This is of weatherproof design, is mistake-proof in operation, and its construction facilitates the making of the jumper connections. The contacts are spring-loaded, and any ice seal which may be formed during extreme climatic conditions is broken by normal operation. 22 kV. insulators are fitted as standard. The unit is suitable for use either with the "English Electric" Type E.30 high-rupturing-capacity non-deteriorating fuse or the "English Electric" expulsion-type re-wirable fuse.

Some Problems of Rural Electrification.

(Reprint of a Paper read on 18th January, 1933, before the Belfast Association of Engineers, by R. M. CHARLEY, B.Sc., M.I.E.E.; continued from Page 137, Vol. VI., No. 5.)

Single-phase Load from Three-phase Supply.

Occasionally requests are made for a manufacturer to supply a transformer suitable for transforming from a three-phase supply to a single-phase load. I urge that in such cases an ordinary single-phase transformer should be used, with its primary winding connected across a pair of lines of the three-phase supply. A special transformer can be made, but after comparing its electrical characteristics as regards current ratio and internal power factor with those of a simple single-phase unit it is seen that nothing is gained by using the special design, which must cost more. The comparison of the electrical characteristics is as follows :—

	Ratio of Currents in Lines.	Power Factor of Currents.
3-phase/1-phase transformer ...	1–2–1	0·5–1·0–0·5
Single-phase transformer ...	1–1	0·866–0·866

Problem of Voltage Regulation.

The unbalanced loading of three-phase 4-wire systems is not responsible for all voltage regulation difficulties, for even with balanced loads there is the inevitable voltage drop due to the inductance and resistance of the line. Furthermore, one of the statutory conditions of bulk supply is that it is given at a declared minimum pressure and is allowed a $12\frac{1}{2}$ per cent. increase. Obviously this variation cannot be passed on to the consumer, hence the distribution authority must legislate for suitable voltage regulating equipment to enable a satisfactory supply to be given to its consumers.

Perhaps the first scheme that might be considered is to install voltage regulating equipment at the point of bulk supply. This might take the form of on-load tap-changing on the main transformers which transform the pressure from, say, 33 kV. to 11 kV. Two units would be installed, and it is quite feasible to operate them automatically in parallel and also to provide line-drop compensation.

The use of induction regulators is to be recommended, and in the case mentioned in the last paragraph I suggest the regulator should be connected in the circuit between the incoming and outgoing feeder panels. It has sometimes been suggested that provision should be made for isolating the regulator under load conditions at times when it is not really necessary for its primary purpose. I suggest that this is not worth while. The loss in the regulator is only of the order of 3 per cent. of its inherent output, and on the basis of the capacity of the line it is only perhaps 0·3 per cent., and, furthermore, the light load loss would only amount to about 0·1 per cent. This loss, I suggest, is negligible, and if it were capitalised it would only represent a small part of the cost of the isolating gear. I recommend, therefore, that regulators installed as outlined above should be provided with a simple arrangement of isolation to allow of them being taken out of circuit only when the circuit is not connected to the supply.

Induction Regulators on Distributors.

This scheme of voltage regulation at the point of bulk supply will not always give the necessary good service on all the individual distributors for obvious reasons, and it is most probable that small regulators may have to be installed on every distributor. The induction regulator provides the ideal means of meeting this problem, and I venture to suggest that there are many cases existing to-day where the installation of an induction regulator could easily be justified from the point of view of service, but, further, its cost would be recovered in a few years from the increased revenue resulting from the improved voltage regulation.

It has sometimes happened that engineers have not been familiar with the simple and economic application of induction regulators, and when faced with a voltage regulation problem they have considered increasing the current-carrying capacity of the line. I suggest that in many cases this is of little value and thoroughly uneconomical. An overhead low voltage distributor probably comprises 0·1 sq. in conductors, spaced 15 inches apart, in which case the resistance and reactance drops are about equal. Hence by

doubling the copper cross section the total impedance drop is only reduced by about 20 per cent. It is much more economical to install an induction regulator.

Small induction regulators are now in service in very large numbers for rural electrification work. They are usually automatically controlled, and are sometimes provided with line-drop compensation. They can easily be arranged for outdoor service and even for pole-mounting. Fig. 8 illustrates such an induction regulator. It has an internal capacity of 5 kVA., which means it can be designed to give, say, plus and minus 5 per cent. regulation on a 100 kVA. distributor, or, say, plus and minus 10 per cent. regulation on a 50 kVA. circuit.

The application of interconnected-star balancers has been described above, but they naturally cannot overcome inherent voltage drop in the distributors. Induction regulators must be installed for this purpose, and in many cases a combination of interconnected-star balancer and induction regulator forms a very desirable arrangement.

It has been suggested that an interconnected-star balancer provided with tappings for on-load tap-changing is a suitable alternative scheme. I believe a little consideration will show that it is not a desirable piece of apparatus. Because of the divided windings, there must be two complete sets of tappings and two tap-changing switches. This extra complication is serious, and it is almost certain that the cost would be as much as the separate interconnected-star balancer and induction regulator.

An induction regulator inherently gives equal buck and boost, whereas in some applications only boost is required. In such cases an auto-transformer should be provided to give a permanent boost of half the total amount required, so that the full range of the induction regulator can be utilised. The cost of the auto-transformer is comparatively small and the size of the induction regulator is halved.

Examples of Application of Induction Regulators.

The following examples showing the benefits resulting from the installation of induction regulators may prove interesting :—

Fig. 9 gives particulars of an actual line and also the voltage conditions, and shows the application of the induction regulator, including its associated auto-transformer. It was desired to take a further load at point D, and to enable this to be done with reasonable voltage regulation, it was decided to install the voltage regulating equipment at point C. The maximum load that could be supplied to this distributor without the installation of a regulator, even assuming the permissible pressure at the end of the line may be as low as 206 volts, is 36 kVA. The regulating equipment complete with a balancer for the three-wire system, and the whole mounted in a kiosk, would cost about £175. The result of installing this equipment is that the load that can be supplied is 62·5 kVA., an increase of 74 per cent.

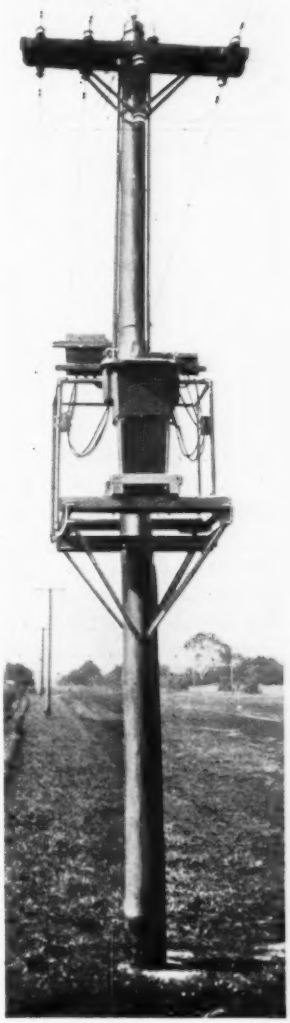


Fig. 8. Pole-mounted Automatic Induction Regulator.

Suppose it is desired to supply a load of about 50 kVA. to a new area located about 900 yards beyond the end of an existing low voltage distributor which is, say 500 yards from the nearest point of high voltage supply. The

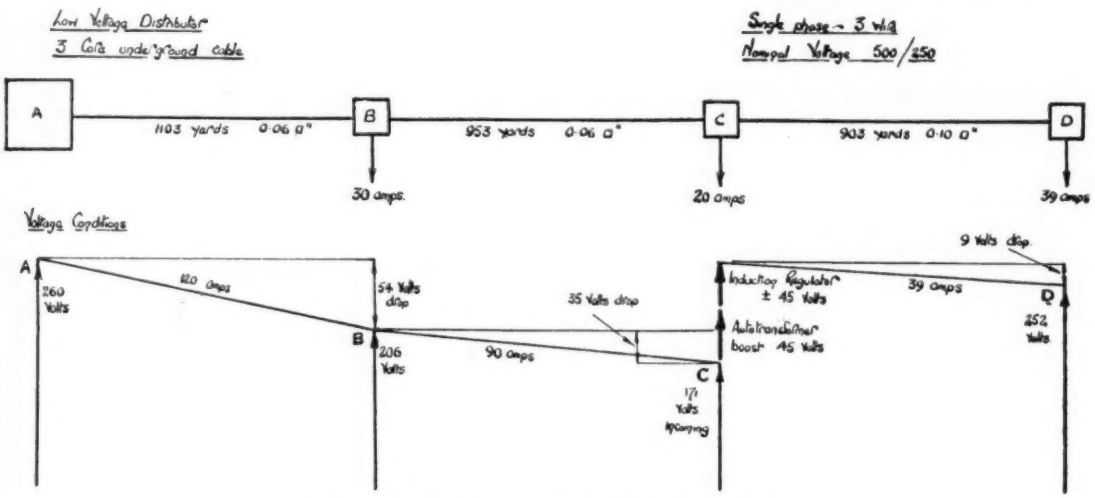


Fig. 9. Example of Application of Induction Regulator.

problem is to decide whether this should be done by an extension of the distributor or by the erection of a new high voltage line. The cost of the former scheme, including the line, auto-transformer and induction regulator, would be about £380, whereas the alternative proposal would cost about £470 for the line, transformer and switchgear. Obviously, the installation of the induction regulator is economical in this case.

Fig. 10 gives some interesting curves showing the great benefits derived from the use of regulated lines. The curves are plotted for three-phase, four-wire, 400-volt overhead lines, assuming the load is at the end of the distributor, and that the power factor of the load is 0·8 per cent. It is seen that the cost per kW. mile of line for the regulated line is of the order of one-quarter the cost of the unregulated line where 4 per cent. voltage drop only is allowed, and there is the further advantage that with the former the voltage is maintained constant at the point of the load.

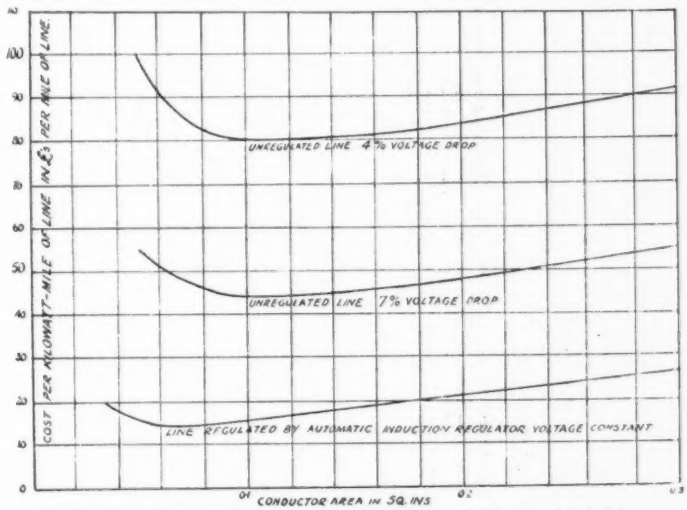
ALTERNATIVE VOLTAGE REGULATING SCHEMES.

Other forms of voltage regulators have been proposed, but they are all generally discredited as compared with induction regulators, except, perhaps, from the point of view of initial cost; but this is more than offset by other considerations. The most recent type of regulator put on the market is known as a moving-coil regulator. Its first and only recommendation is that it is cheap, but its losses are inherently higher than for an induction regulator. Another very important feature is that since its function as a voltage regulator is dependent on its inherent reactance, it must give a comparatively large phase displacement. It is true that a simple induction regulator also has phase displacement, but this can be overcome by using a twin unit regulator. No such scheme can be adopted with the moving-coil type of regulator. Hence, apart from its other drawbacks, there are applications, such as a ring main or interconnected distributors, where this type of regulator could not be installed.

Occasionally a problem arises where the installation of an induction regulator cannot be justified, but some means of raising the voltage must be provided. To meet this demand, I suggest a small auto-transformer arranged to give perhaps three different voltages in two equal steps, tap-changing being carried out by means of contactors which are automatically operated by a system of thermal relays which are controlled from a current transformer. In this simple manner the voltage can be made to increase in steps of any reasonable value, as the load increases. This scheme is shown diagrammatically in Fig. 11.

Improving Load Factor and Load.

It will not be disputed that one of the biggest problems of rural electrification is the improvement of load factor. Not only is this necessary to enable the cost of generation to be reduced, but it would have other advantages in distribution. At 100 per cent. load factor voltage regulation troubles would largely disappear, for the transformer voltage ratio and other characteristics could be chosen to give the best possible conditions under full load without undue attention being paid to light loads. I venture to suggest that Supply Authorities should intensify their campaign to encourage the use of devices that will improve load factor. I have in mind water heating and heat storage cookers, and there may be other schemes for absorbing power at off-peak times. Furthermore, greater efforts might be made to increase load generally apart from the question of load factor. The average electric lighting of houses, shops or offices cannot be described as ideal at present. Better lighting would increase domestic comfort, increase sales in shops, and result in higher efficiency in offices. Much can be done to increase load in this direction.


COST PER KILOWATT-MILE OF LINE IN £'S PER MILE OF LINE
UNREGULATED LINE 4% VOLTAGE DROP
UNREGULATED LINE 7% VOLTAGE DROP
LINE REGULATED BY AUTOMATIC INDUCTION REGULATOR VOLTAGE CONSTANT
CONDUCTOR AREA IN SQ. INS

* *Fig. 10. Comparative Costs of Regulated and Un-regulated Lines.*

Future Developments.

It will be generally accepted that only the fringe of the possible rural load has yet been touched, and I venture to suggest that greater vision might be exercised in the conception of future schemes. The capacity of transformers should be sufficiently great to allow for an increase in load of several times the present demand. I would also suggest that higher pressure for distribution should be seriously considered. 11 kV. is not high enough for general use in distribution if loads contemplated are several times their present values. I consider that distribution at 33 kV. must be more universally adopted, and assuming that transformers of comparatively large output are installed, and allowing for the fact that the intermediate voltage transformation from 33 kV. to, say, 11 kV. is eliminated, it would be found that 33 kV. distribution would be a sound proposition. This policy demands long vision and the pioneering spirit, but it would pay in the long run.

In conclusion I trust that my remarks concerning apparatus required for rural electrification schemes will be of some value to operating engineers, and also that the observations I have dared to make regarding the conception of future schemes may at least result in a new line of thought.

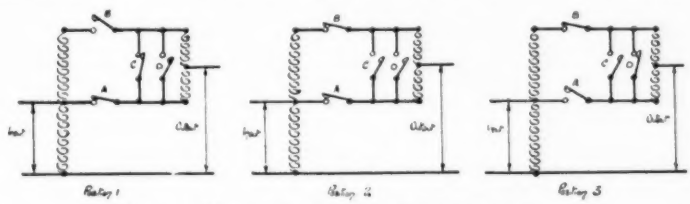


Fig. 11. Diagram for Two-step Booster Transformer.

* Curves of Un-regulated Lines are plotted from information given in the paper entitled "The Design of a Distribution System in a Rural Area," by E. W. Dickinson and H. W. Grimmitt, published in the Journal of the Institution of Electrical Engineers, February, 1932.

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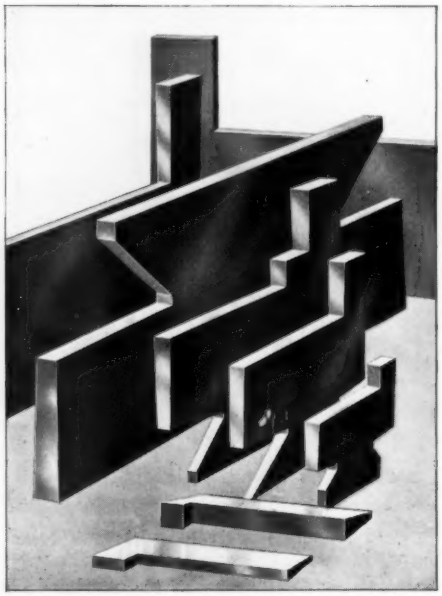

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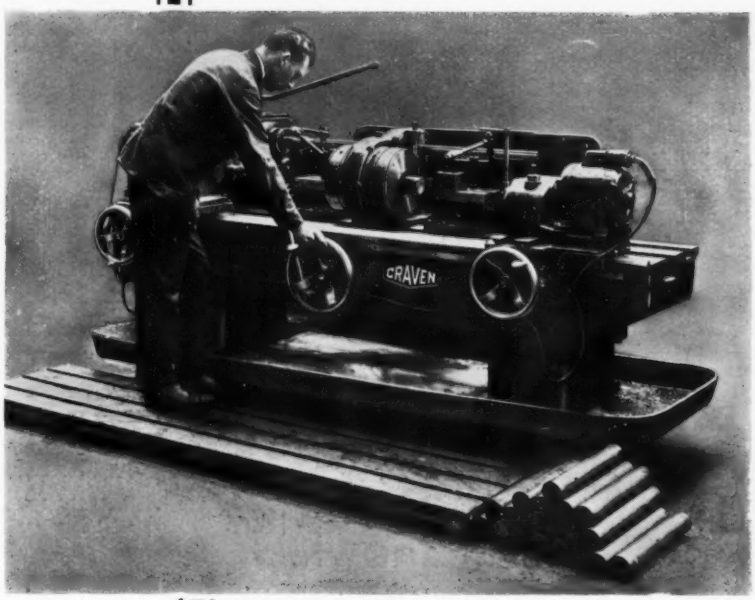

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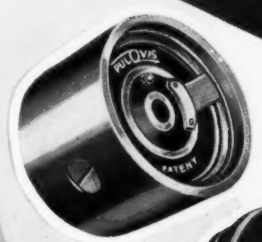

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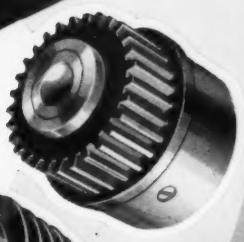

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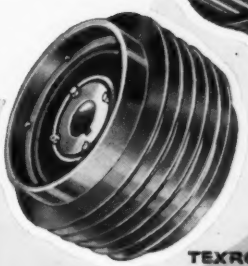

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